PATTERNING OF BEHAVIOR IN A CONCURRENT VARIABLE-INTERVAL SCHEDULE AS A FUNCTION OF THE CHANGEOVER DELAY

An abstract of a Thesis by
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The problem. The present study was conducted to determine the temporal placement of licking in a concurrent schedule of reinforcement and to see how various changeover delays affect the temporal placement of licking.

Procedure. Rats were trained to press a lever for food. Food was made available by two independent reinforcement schedules, separated by a changeover delay. The changeover delay was varied over a range of 0 to 8 seconds. A drinking tube was freely available in the experimental chamber. Numerical data were obtained on the frequency of lever pressing, lick episodes, and their temporal patterning.

Findings. Changeover response rates showed a systematic change in accordance with the length of the changeover delay. Response rates showed a systematic change only for animals which were exposed to signalled changeover delays. These animals tended to engage in licking following the delivery of a pellet, whereas animals exposed to unsignalled changeover delays tended to engage in licking following foodlever presses. Licking never occurred during the changeover delay. Changeover responses were maintained when their only effect was a possible delay of the reinforcement in a simple variable interval schedule.

Conclusion. A changeover delay is not a necessary condition to obtain matching. The length and the type of changeover delay does affect the patterning of behavior. The increase in overall response rates with longer changeover delays, the occurrence of changeover responses in a simple variable interval schedule, and the absence of licking during the changeover delay indicate that the changeover delay is a period of high probability of reinforcement which maintains high rates of behavior.

Recommendations. It was recommended that a broad range of changeover delays be examined in terms of their effect on the rate and temporal patterning of both the foodlever responses and the changeover responses.

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CHAPTER I

INTRODUCTION

If food-deprived rats are exposed to schedules of intermittent food reinforcement, they will ingest excessive quantities of water (polydipsia) in an experimental session, given the opportunity to do so (Falk, 1961). Falk's initial emphasis on the quantity of ingested water led to the post-prandial or "dry mouth" hypothesis (Stein, 1964). Kissileff (1969) reported that most drinking occurred shortly after food consumption. This would suggest that as the number of discrete meals is increased, the number of licks and thus consumption of water would also increase. Manipulation of the reinforcement density, however, revealed a bitonic function where the water intake (ml/min) increased with increasingly denser fixed interval (FI) schedules up to FI 15-sec and then decreased for values smaller than 5 seconds (Flory, 1971). Falk (1967) also showed that dry, solid food was not a necessary condition for the development of polydipsia. Substituting Standard Monkey Diet suspended in a liquid for the normally used pellets produced polydipsia in rats. If the availability of water is restricted during the interreinforcement interval by interposing a 15 second delay between food and the opportunity to drink, rats still develop polydipsic licking (Flory & O'Boyle, 1972). Polydipsic licking occurs even

when an airstream is substituted for water, which suggests that the water itself is not a necessary condition for the excessive behavior (Mendelson, Zielke, Werner & Freed, 1973).

Temporal and sequential characteristics in the inter-reinforcement interval (IRI) are another important aspect of schedule induced or interim behaviors. Several studies have demonstrated that different behaviors such as drinking and wheel running occur in a sequence and in a predictable temporal location during the IRI (Staddon & Ayres, 1975; Staddon & Simmelhag, 1971). Clark (1962) proposed the superstition hypothesis of polydipsia and suggested that a pellet-licking-pellet sequence might superstitiously reinforce licking, due to its close temporal contiguity to the terminal reinforcer. This hypothesis would not explain why other activities that are initially contiguous with food would disappear after the behavior has stabilized. Flory and O'Boyle (1972) demonstrated that temporal contiguity is not a necessary condition for polydipsia, which is further evidence against the adventitious reinforcement hypothesis.

An alternative approach based on the discriminative properties of food delivery has been suggested by Falk (1969). According to this theory, drinking occurs when the probability of reinforcement is low. Rosenblith (1970), using a second order FR 3 (FI 1-min) schedule, showed that

drinking occurred after the presentation of a stimulus following the completion of a component schedule, as well as after food delivery. Similar results were obtained by Porter and Kenshalo (1974). Even when the signal that follows the component schedules was never paired with food, licking was observed after the occurrence of the brief stimulus (Corfield-Sumner, Blackman & Stainer, 1977). Alferink, Bartness, and Harder (1980) showed that on a mix FR 10 chain FR 10 FR 90 schedule, a tone following the completion of the chained FR 10 component controlled licking, and that drinking occurred after the tone when its temporal location was manipulated. The discriminative properties of pellet deliveries would explain the failure of polydipsia to develop in random interval food reinforcement schedules (Millenson, Allen, & Pinker, 1977). In this type of schedule each time period is equally eligible for reinforcement according to some probability, so that the delivery of reinforcement has no or little discriminative properties concerning the probability of a subsequent pellet delivery.

In a concurrent schedule of reinforcement, two independent and continuously available schedules of reinforcement determine the availability of food. Procedurally, concurrent schedules can be programmed so that two manipulanda are available, each being associated with one independent schedule (Catania, 1966), or when one manipulandum is associated with the reinforcement schedules, while the

second manipulandum enables the organism to switch from one reinforcement schedule to the other (Findley, 1958). Herrnstein (1970) has shown that matching or relative response rate to relative reinforcement frequency occurs according to the equation $B_1/(B_1+B_2) = R_1/(R_1+R_2)$. A changeover delay (COD) following the changeover response is usually implemented to separate the two schedules (Herrnstein, 1961). Matching in this experiment was only obtained with the implementation of a COD of 1.5 seconds. Without a COD, simple alternation between components occurred which suggested an adventitious reinforcement of the changeover response. Catania and Cutts (1963) showed that without a COD, responding on both keys occurred at an equal rate, even if one component of the concurrent schedule was changed to extinction. During a COD, lever presses are never followed by pellets. Todorov (1971) used a time-out (TO) period following a changeover response in a concurrent schedule and obtained similar results as compared to a COD. A COD could thus be considered a period of TO from reinforcement, during which the probability of reinforcement is low. According to Falk, licking should occur during the COD in a concurrent schedule.

The current study was conducted to determine the placement of licking in the concurrent schedule and to see if the length of the COD, during which the probability of food delivery is zero, may be a controlling factor of lick

behavior. To enhance the controlling relationship, a visual signal providing a discriminative stimulus for the subjects, was added to the COD for part of the experiment. This procedure made a comparison between signalled and unsignalled CODs possible.

CHAPTER II

METHOD

Subjects

Four experimentally naive male albino rats served as subjects. Each subject was maintained at approximately 80% of its unrestricted feeding weight for the duration of the study. Water from a calibrated glass tube was available continuously in the home cage, and intake volumes were measured daily at approximately the same time.

Apparatus

Experimental sessions were conducted in one two-lever chamber constructed of clear plexiglass, 30.5 cm x 35 cm. Each lever was located 8 cm from the floor grid and 2.25 cm from each side of the vertical midline of the response panel. The operant chamber was enclosed in a sound attenuated shell. A minimal force of 0.2 N on either lever defined a response. The food tray was mounted at equal distances from each response lever on the response panel. The drinking tube, which extended 1 cm into the chamber, was located on the wall opposite the response panel, so that the animal could not engage in drinking and bar pressing at the same time. A light which provided a visual stimulus during the COD was mounted above each response lever. A single 7.5 W white lamp, which provided illumination during the

experimental sessions, was located at the top of the right front of the sound attenuating chamber. Masking noise was provided by an exhaust fan and an 8 ohm speaker. Solid state logic (BRS-LVE) was used to program and conduct the experimental sessions.

Procedure

The initial shaping procedure began after the animals' weight was reduced to 80% of their free feeding weight, and a stable water baseline had been obtained for five consecutive days. The lever press response to the food lever was established by reinforcing successive approximations to the target response. During shaping, two tones alternated randomly. A response to the food lever went unreinforced until a response to the changeover lever had occurred. This changeover response turned on one of the two tones on a random basis, after which a response on the food lever produced a food pellet. When responding on the food lever was consistently followed by a response on the changeover lever, an alternating sequence of the two tones was introduced following responses on the changeover lever. At the same time the behavior chain with one terminal reinforcer was changed to a concurrent schedule of continuous reinforcement. In the concurrent schedule the animal received continuous reinforcement in one component until a changeover response occurred, at which point the other component with

its characteristic tone and the continuous reinforcement schedule became effective. The schedule of reinforcement was then changed to concurrent VI VI schedules, which were gradually increased until a concurrent VI 60-sec VI 60-sec schedule was obtained. All variable interval schedules were generated using an arithmetic probability progression (Catania & Reynolds, 1968). The discriminating stimuli associated with the components of the concurrent schedule were a high frequency tone (H) for one, and a low frequency tone (L) for the other component, both of which remained the same throughout the experiment. When the initial response requirement was increased to a concurrent VI 10-sec VI 10-sec schedule, a 4 sec COD was introduced to prevent superstitious reinforcement of the changeover response. Responding on the food lever during the COD did not produce a reinforcer, but if the variable interval associated with the component currently in effect had elapsed, the first response after the COD would be followed by the delivery of a pellet.

After a stable performance had been reached on the concurrent VI 60-sec VI 60-sec schedule of reinforcement, the drinking tube was introduced and the COD was increased to 8 seconds. During this and the next three experimental conditions, CODs were signalled for two animals and unsignalled for the other two animals. All experimental conditions remained in effect for at least ten days and until the

behavior of the animal had stabilized for five days. Stable responding was determined by measuring the water consumption during each session and by visual inspection of the temporal location of the drinking. Lever pressing was considered stable when the deviation from obtained matching was no greater than 0.1, and by visual inspection of the changeover response rate. Following stabilization the COD was changed to 4 seconds, and this experimental condition was maintained until the behavior stabilized. Next, the COD was eliminated (0 sec COD), so that a changeover response could be followed by a reinforced response on the food lever. A reversal was then introduced to recover the previously established level and temporal distribution of the behavior.

In the final experimental condition, an unsignalled COD of either 4 or 8 second duration was introduced for those animals that had previously been exposed to the signalled CODs. The unsignalled 4 second reversal for the other two animals was followed by a VI 60-sec schedule of reinforcement, where responding on the food lever following a response on the changeover lever, did not produce a reinforcer at the end of the variable interval until a 4 second delay had elapsed. Since a single VI 60-sec schedule was in effect, no component alternation occurred following the changeover response. Daily sessions terminated after 120 pellets for the concurrent schedule and 60 pellets for the variable interval schedule had been obtained. Following

the conclusion of the experimental manipulations, a second water baseline was obtained for each animal. Table 1 depicts the sequence of experimental manipulations for each subject.

Lick episodes, defined as continuous licking without the occurrence of intervening bar presses, were recorded for each of the following cases:

a) postpellet (PP), i.e. following the delivery of a pellet.

b) postfood-lever response (PFL), i.e. after a response on the food lever had occurred without a pellet being delivered.

c) postchangeover response (PCOR), i.e. immediately following a response on the changeover key.

d) changeover delay (COD), i.e. when the COD was in effect. This last measure included lick episodes following responses on the food lever while the COD was still in effect.

Table 1

Order in which the Different CODs were Presented to each Subject

Condition	Subjects			
	Bl01	Bl02	Bl03	Bl04
1	Baseline 1	Baseline 1	Baseline 1	Baseline 1
2	8 sec signalled COD	8 sec signalled COD	8 sec unsignalled COD	8 sec unsignalled COD
3	4 sec signalled COD	4 sec signalled COD	4 sec unsignalled COD	4 sec unsignalled COD
4	No COD	No COD	No COD	No COD
5	4 sec signalled COD	4 sec signalled COD	4 sec unsignalled COD	4 sec unsignalled COD
6	8 sec unsignalled COD	4 sec unsignalled COD	VI 60/4 sec COD	VI 60/4 sec COD
7	Baseline 2	Baseline 2	Baseline 2	Baseline 2

CHAPTER III

RESULTS

The level of water consumption for each rat, averaged over the last five sessions of each experimental condition, is presented in Table 2. Water consumption during Baseline 1 was measured for five days prior to shaping. Water consumption during Baseline 2 was measured for five days after the termination of the experiment, or after water consumption had stabilized for five consecutive days. A comparison of pre- and post-experimental drinking shows a slight increase in the average consumption, but a comparison of the variation in water consumption does not reveal any systematic differences. During the experimental conditions, home cage consumption decreased on the average from 38.5 ml to 23.9 ml for Bl01, from 29.3 to 7.1 ml for Bl02, from 39.1 to 24.8 ml for Bl03, and from 32.8 to 13.6 ml for Bl04. The water intake during the experimental sessions, which lasted for approximately 90 minutes, exceeded the 24 hour baseline water intake for all four animals, with the exception of the simple VI 60-sec schedule (Bl03, Bl04). Overall water intake increased twofold and sometimes threefold (Bl04, no COD) while the experiment was in progress as compared to baseline water intake, which indicates that all four animals became polydipsic.

The data presented in Table 3 were taken from the last

Table 2

Means and Ranges of Water Consumption (ml) During the Last 5 Days of each Experimental Condition, Including a 5 Day Pre- and Post-Experimental Water Consumption Baseline

Condition	Subject	Cage	Chamber	Total
Baseline 1	B101	35.2(31-47)		35.2(31-47)
8 sec COD, sig.		27.8(17-37)	58.4(54-70)	86.2(78-97)
4 sec COD, sig.		26.6(20-49)	49.0(35-66)	75.6(61-84)
No COD		25.8(11-40)	54.0(51-58)	79.8(67-98)
4 sec COD, sig.		17.4(11-26)	46.0(37-52)	63.4(55-76)
8 sec COD		22.0(13-31)	56.2(45-63)	78.2(75-82)
Baseline 2		41.8(36-49)		41.8(36-49)
Baseline 1	B102	28.0(25-33)		28.0(25-33)
8 sec COD, sig.		4.6(3- 8)	38.0(28-46)	42.6(32-54)
4 sec COD, sig.		9.8(2-16)	66.6(59-83)	76.4(62-91)
No COD		6.2(2-14)	78.2(70-83)	84.4(78-94)
4 sec COD, sig.		7.4(5-13)	62.8(59-72)	70.2(65-77)
4 sec COD		7.6(3-14)	56.6(48.65)	64.2(53-75)
Baseline 2		30.6(27-33)		30.6(27-33)
Baseline 1	B103	34.6(31-36)		34.6(31-36)
8 sec COD		21.6(15-32)	61.4(54-68)	83.0(74-100)
4 sec COD		21.2(11-27)	51.0(45-56)	72.2(56-82)
No COD		22.4(12-30)	45.6(31-56)	68.0(43-78)
4 sec COD		26.8(8-43)	73.6(70-76)	100.4(85-116)
VI60		32.2(22-37)	21.6(19-24)	53.8(44-59)
Baseline 2		43.6(41-47)		43.6(41-47)
Baseline 1	B104	32.2(23-38)		32.2(23-38)
8 sec COD		9.2(5-11)	55.2(46-64)	64.4(57-74)
4 sec COD		5.6(2- 9)	61.6(55-68)	67.2(58-77)
No COD		15.8(2-23)	56.4(44-69)	72.2(55-86)
4 sec COD		12.6(10-16)	48.2(44-50)	60.8(56-66)
VI60		24.6(13-33)	27.4(22-30)	52.0(41-63)
Baseline 2		33.4(28-35)		33.4(28-35)

Table 3

Original Data Averaged Across the Last Five Sessions of each Experimental Condition

Condition	Subject	Sessions	COR	Responses High	Responses Low	Time (min) High	Time (min) Low	RFR High	RFR Low
8 sec COD, sig.	B101	30	194	2068	1857	52	51	61	59
4 sec COD, sig.		21	237	1553	1521	44	45	57	63
No COD		44	341	1237	1218	42	43	57	63
4 sec COD, sig.		14	268	1304	1341	42	44	60	60
8 sec COD		13	166	1866	1841	51	50	61	59
8 sec COD, sig.	B102	31	142	2980	3050	46	48	60	60
4 sec COD, sig.		17	214	2663	2526	41	43	59	61
No COD		19	285	1970	1950	42	46	56	64
4 sec COD, sig.		26	291	2675	2694	39	45	54	66
4 sec COD		24	155	2101	2118	44	43	62	58
8 sec COD	B103	74	111	1205	1225	52	58	54	66
4 sec COD		19	98	1141	1128	47	51	56	64
No COD		44	80	1073	1092	40	41	60	60
4 sec COD		12	86	1389	1506	43	43	61	59
VI 60/4 sec COD		16	69		3920		69		60
8 sec COD	B104	74	166	1123	1091	48	54	56	64
4 sec COD		18	222	1351	1194	45	50	56	64
No COD		35	372	899	878	40	40	61	59
4 sec COD		22	234	1035	1061	44	41	63	57
VI 60/4 sec COD		11	118		2335		70		60

five sessions in each experimental condition, and represent an average across the last five days. The Sessions column specifies the total number of daily sessions of each experimental condition. Variations in the number of sessions between conditions and between animals are due to the preimposed criteria for stability. The mean number of changeover responses for the last five sessions in each experimental condition is depicted in the COR column. The Response column shows the average total number of responses in the high and low tone components for each experimental condition. The last two columns show the total time spent and the total number of pellets delivered in the high and low tone components of the concurrent schedule, averaged over the last five days of each experimental condition.

Figure 1 shows the response rates (R/min) averaged over the last five days of each experimental condition. The response rate for Bl01 and Bl02 showed a systematic decrease, with the highest response rate occurring when an 8 sec COD was implemented. The lowest response rate was emitted when no COD was implemented. During the reversal condition, the response rate increased to the previously established level for Bl02, whereas the response rate remained somewhat below the previously established level for Bl01. Changes in the response rates were less systematic for Bl03 and Bl04.

Figure 2 shows the relative response rate and the relative time spent in the high tone component, as a function

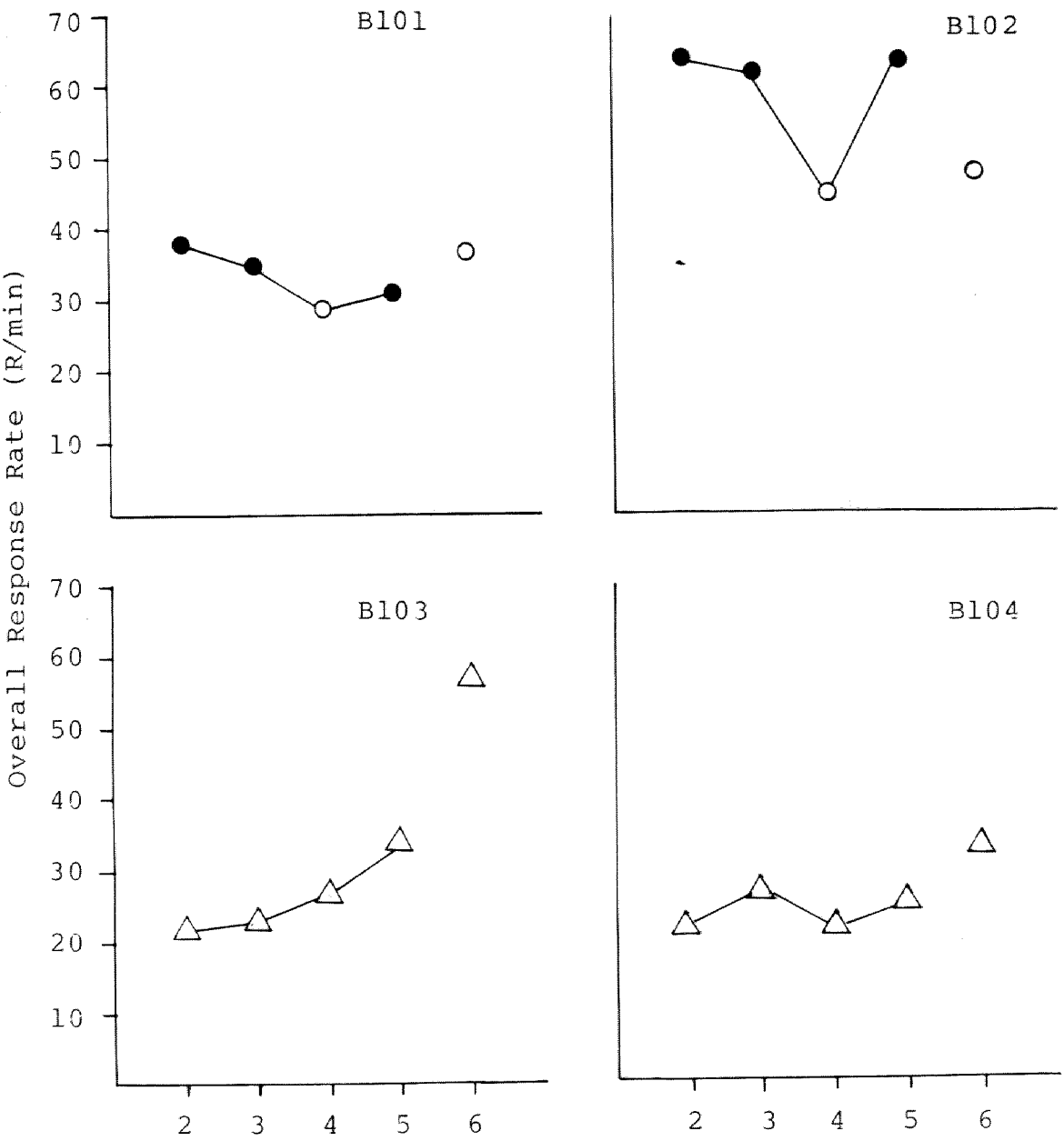

Figure 1. Overall response rate as a function of the COD duration averaged across the last five days of each experimental condition (filled circles-signalled CODs; open circles-unsignalled CODs).

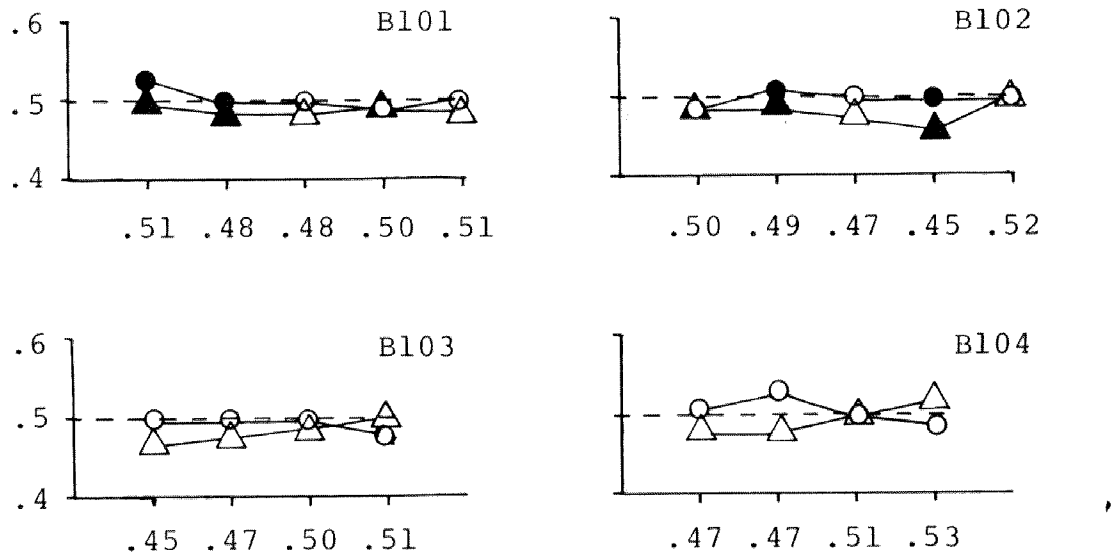

Figure 2. Relative response rate and relative time spent in the high tone component of the concurrent schedule as a function of the obtained relative rate of reinforcement (circle-R_H: triangle-T_H).

of the obtained relative rate of reinforcement, averaged across the last five days of each experimental condition. The measures approximate both the matching line (0.50, scheduled reinforcers) and the obtained relative rate of reinforcement of the concurrent VI 60-sec VI 60-sec schedule of reinforcement. The obtained relative time distribution more closely approximates the obtained relative rate of reinforcement as compared to the relative response rate. The individual data points within each condition, not represented here, show slightly more deviation from the matching line, but they all fall within the specified stability criteria.

Figure 3 shows the changeover response rate (COR/min) averaged over the last five sessions of each experimental condition. Changeover rates increased as a function of decreasing COD length for all four animals. Responding on the changeover key was highest when no COD was in effect, with the exception of B102. During the 4 sec signalled COD reversal condition, CO responding increased above the level established during the 0 sec COD condition for B102. Changeover responding for B101 and B102 was higher during each condition when the COD was signalled rather than unsignalled. B101 responding on the CO key decreased to an average of 1.66 times per minute during the unsignalled condition, as compared to 1.88 during the signalled COD. Similarly, the CO response rate for B102 was 2.6 and 2.9

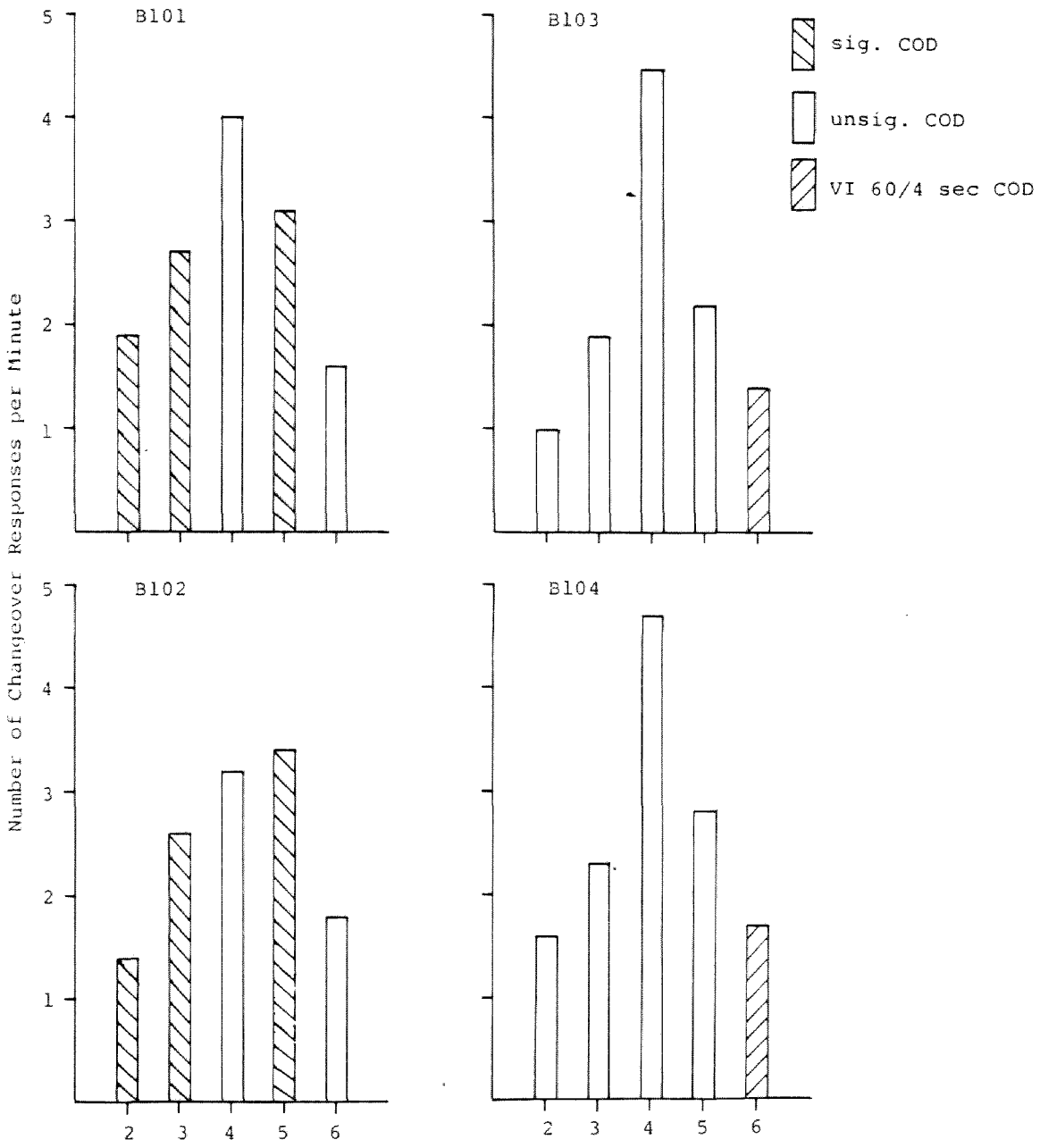

Figure 3. Changeover response rates as a function of the different COD durations averaged across the last five days of each experimental condition.

during the signalled 4 sec COD as compared to 1.8 during the unsignalled 4 sec COD. Overall, CO rates were lower for the animals in the unsignalled conditions when a COD was in effect. The increase in CO responding for B103 and B104 during the 0 sec COD condition was steeper when compared to previous and subsequent conditions where a COD was in effect. CO responding for both animals during this condition was higher when compared to the CO responding of B101 and B102. During the reversal, CO responding returned to the previously established levels. During the final condition, a simple VI 60-sec schedule of reinforcement was in effect. CO responding resulted in a 4 sec COD and both animals maintained a stable rate of CO responding.

Figure 4 shows the temporal distribution of lick episodes averaged across the last five days of each experimental condition. Lick episodes occurred postpellet and postfood-lever, but never after a changeover response or during a changeover delay. For B101 and B102, the majority of lick episodes occurred postpellet. B103 and B104 engaged in postfood-lever licking more often when compared to the animals in the signalled COD conditions. B103 exhibited postfood-lever licking almost exclusively. With the exception of B103, postfood-lever licking occurred most frequently during the No COD condition. For B103, postpellet licking never occurred during this condition. During the VI 60-sec schedule, both animals engaged in postfood-lever

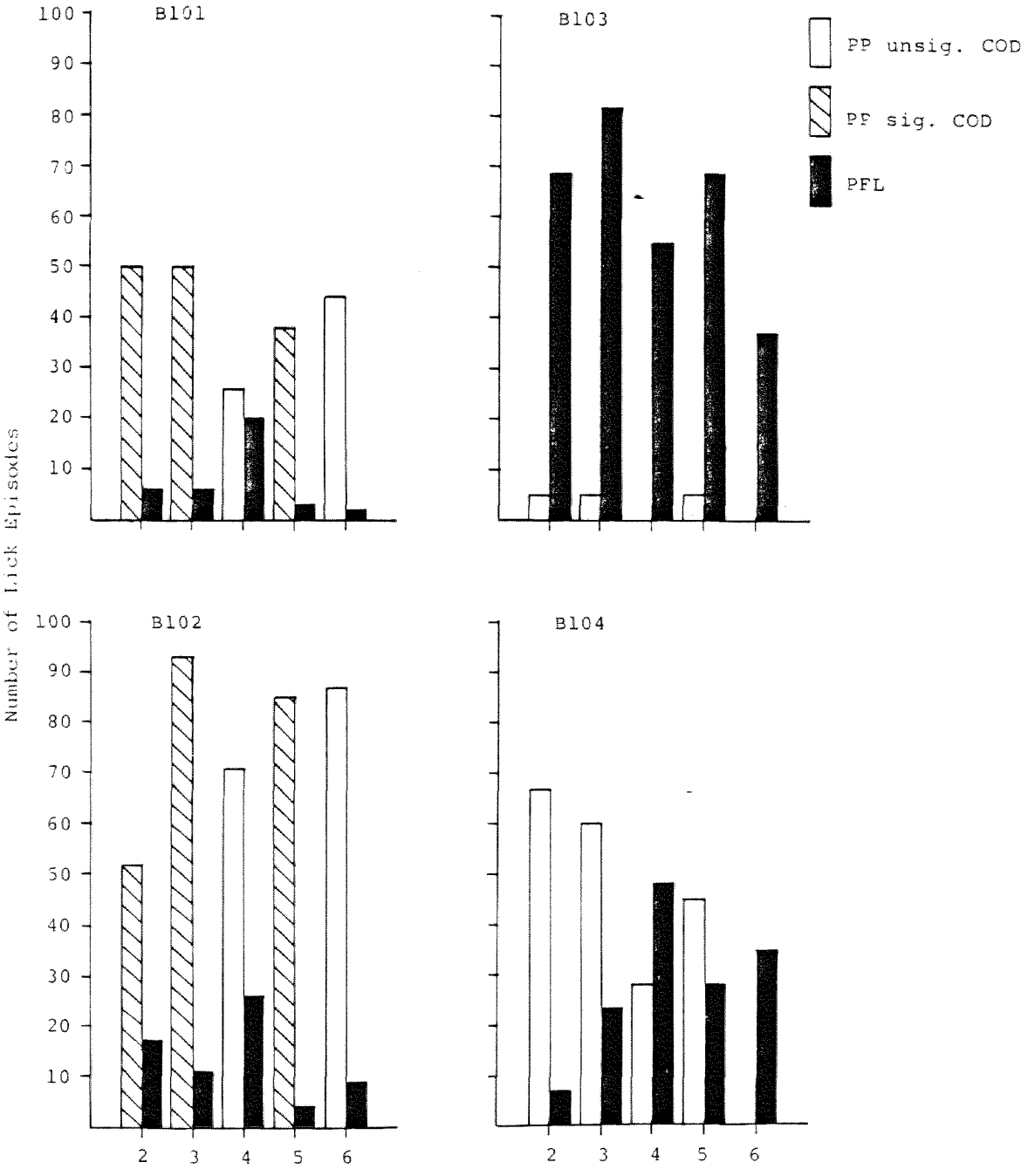

Figure 4. Number of lick episodes (postpellet and postfood-lever) as a function of the length of the COD.

licking exclusively. The number of lick episodes varied from condition to condition for all animals but showed no systematic changes. Temporal location of the lick episodes recovered during the reversal condition for all animals. A comparison between the number of lick episodes (Fig. 4) and the amount of water consumed during the experimental session (Table 2) shows no correlation between the two measurements. The same was true for a comparison between the number of licks, the amount of water consumed, and the number of lick episodes.

CHAPTER IV

DISCUSSION

The present experiment examined the effects of various CODs on the pattern of polydipsic licking in a concurrent schedule. The majority of lick episodes for the signalled CODs occurred following food delivery, which may be attributable to the low probability of reinforcement immediately after food presentation (Falk, 1969). A large number of lick episodes were recorded as postfood-lever for Bl03 and Bl04. Some of these postfood-lever lick episodes may be a recording artifact, due to the COD response run lasting into the post-COD period. Note, however, the increase in postfood-lever licking which occurred for signalled animals at 0 sec COD. This, in combination with the postfood-lever licking which occurred during other COD values for these animals, suggests that after a COD and an unreinforced food lever response, the probability of reinforcement may be low. No lick episodes occurred during the CODs which suggests that the function of the COD in concurrent schedules should be reexamined.

Herrnstein (1961) advocated the implementation of a COD following a changeover response in a concurrent schedule of reinforcement, to prevent the superstitious reinforcement of the changeover response and thus prevent simple alternation between the components of the concurrent schedule.

These findings were further substantiated by Catania and Cutts (1963). More recent experiments (Baum, 1974; Stubbs & Pliskoff, 1969; Heyman, 1979) have shown that the COD is not an essential requirement for obtaining the matching relationship. In this experiment, matching was obtained across a number of manipulations of the COD, including matching between relative rate of responding and relative rate of reinforcement when no COD was implemented. It should be pointed out, however, that equal VI components were in effect throughout the experiment, and that the COD was only omitted after extensive exposure to concurrent schedules which included a COD. With equal component reinforcement frequencies, matching would have been obtained even if rapid switching between the components had occurred. Local changeover rates suggest that simple alternation did not occur, since on the average at least thirteen seconds were spent in one component before a changeover response occurred. For the animals in the signalled COD conditions, changes in changeover response rates were even less pronounced when the COD conditions are compared to the no COD condition. The change in changeover rate was similar to that of Brownstein and Pliskoff (1968) and further substantiates findings by Herrnstein (1961) and Shull and Pliskoff (1967), who showed that the changeover rate is a negatively accelerated decreasing function of the COD duration.

Aside from its effects on the matching relationship, however, manipulation of the COD seems to exert control over the response rates on the food lever and the changeover lever, and the temporal patterning of lick behavior. In this experiment, the overall response rate was inversely related to the length of the signalled COD and a similar pattern, although less clear, could be observed for at least one animal in the unsignalled COD conditions. A reevaluation of Todorov's data (1971, Table 3) shows a similar pattern when the length of a TO following a changeover response was manipulated. Silverberg and Fantino (1970) examined the local response rate separately during the COD and post-COD. They found that a response on the changeover lever is usually followed by a response run on the food lever, the temporal duration of which is directly related to the length of the COD, but which lasts one or two seconds into the post-COD period. Examination of the lick pattern (Fig. 4) and observations during the experimental sessions confirm these and similar findings (Pliskoff, Cicerone, & Nelson, 1978). A large number of lick episodes which occurred postfood-lever, especially during the unsignalled condition, were due to the response run which lasted into the post-COD period, thus registering postfood-lever lick episodes when a pellet was delivered following the expiration of the COD. A signal added to the COD resulted in a COD response burst which terminated with the

termination of the COD signal light.

Killeen (1972) compared concurrent schedules to multiple schedules in a yoked experiment, and found that response rates were higher (83 vs. 50 responses per minute) for the concurrent schedules. Automatic changeovers resulted in a 21% decrease of the local response rate in that schedule. He concluded that the local response rate is directly related to the local probability of reinforcement. Stubbs, Pliskoff, and Reid (1977) related the effects of the COD to "time estimation" and "temporal judgments," in that the temporal properties of the environment have some effect on the temporal aspects of behavior. Response bursts during the COD seem to be related to the passage of time and the change in local probability of reinforcement during this time. In the signalled COD conditions, the passage of the COD was indicated by a stimulus in addition to the passage of time itself. The response burst terminated when the light terminated, which suggests that the continuation of the response run into the post-COD period is due to a poor control by time as a stimulus. The generally higher local response rate of the signalled COD animals as compared to the unsignalled COD animals, tends to support this point of view.

Pierce, Hanford, and Zimmerman (1972) used a reinforcement delay procedure to investigate the effects of delay of reinforcement on the response rate of a VI schedule.

Response rates increased markedly toward the termination of the delay as compared to response rates during the VI schedule. In a concurrent schedule, the change from one component to the other usually occurs after some time has been spent in the component currently in effect. The probability of reinforcement in the second schedule increases over time, so that the COD is often followed by a reinforced response. The COD in a concurrent schedule is thus comparable to this delay procedure.

Pliskoff (1971) suggested that the COD functions to punish the CO response, since it produces this delay of reinforcement. The results of this experiment suggest a somewhat different explanation. If the delay is functionally equivalent to punishment which suppresses CO responding, any additional signal indicating the length of the delay should suppress responding more than an unsignalled delay. In this experiment, however, changeover rate was generally higher in the signalled condition. Furthermore, the increase in changeover responses during the no COD condition was higher for the unsignalled animals. Changeover responding would be expected to extinguish rapidly if the delay had only punishing aspects. Yet, changeover responses continued to be emitted during the simple VI 60-sec schedule, only to produce a possible delay in reinforcement. These data suggest that the changeover response and the COD may produce stimuli which accompany the reinforcer, which

frequently follows the first response after the COD elapses. These stimuli may function as conditioned reinforcers. The conditioned reinforcement hypothesis states that the higher the density of reinforcement in the presence of a stimulus, the greater the reinforcing strength of that stimulus. As COD duration increases, the density of reinforcement decreases. Thus, as COD duration increases from 0 to 8 sec, the conditioned reinforcing strength of stimuli associated with the COD decrease. This decrease in the conditioned reinforcing strength would account for the decrease in the frequency of changeover responses as COD duration increased. However, this account is complicated by the fact that decreases in the rate of changeover responses would increase the probability that the first response following a COD would produce a pellet. If the COD duration is short, the frequency of changeovers increases which would produce a decrease in the probability that the first response after the COD would be reinforced, which in turn would change the density of reinforcement for stimuli associated with the COD. The data would suggest that the animal responds on the changeover key according to the combined effects of the probability of reinforcement and the density of reinforcement. Discriminative stimuli produced by the changeover response are relatively weak, so that any additional exteroceptive stimuli, indicating the passage of the COD, increase its conditioned reinforcing strength which results in a higher

changeover rate. Conversely, the absence of additional exteroceptive stimuli indicating the passage of the COD would reduce the conditioned reinforcing strength of the COD, which results in a lower changeover rate and a response run which lasts into the post-COD period. The ratio of postfood-lever to postpellet lick episodes was highest when no COD was in effect, or when it did not change the momentary probability of reinforcement (during VI). The fact that no lick episodes occurred during the COD suggests that the probability of reinforcement is high. A stimulus which accompanies a high probability of reinforcement controls high rates of responding in its presence and should also maintain responses which produce this stimulus. This suggests that the current justification for the implementation of a COD in concurrent schedules, to prevent superstitious changeover responding, does not seem plausible.

The present experiment sought to clarify the role of the COD on lick behavior in a concurrent schedule, especially its involvement in the temporal distribution of lick behavior. It was found that: 1) the temporal distribution of lick behavior changes when different COD durations are compared to no COD; 2) signalled vs. unsignalled CODs affected both the response and lick distribution in addition to changeover responding; and 3) changeover responses continued to be emitted in a VI schedule.

It is suggested that future studies further examine the

effects of the changeover delay and changeover responding on both terminal and interim behaviors. Particularly, this study suggests that the COD should be examined in terms of conditioned reinforcement.

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